

Combustion Technologies Program Area Suggestions from Industry

Coordinating Scribe: Richard E. Weinstein

**Evolution of
Combustion
Technology to Support
National Energy Needs
Workshop**

**Sheraton World Resort
Orlando, Florida
January 14-16, 2002**



What Is Discussed Here?

- This presentation shows industry's suggestions for possible R&D and related activities to support Combustion Technologies
- These are drawn from the [Evolution of Combustion Technology to Support National Energy Needs Workshop](#) held in Orlando January 14-16, 2002
- The suggestions are grouped here by product area *(not by the original question that prompted the suggestion)*

For reference convenience, a code is appended to each suggestion, to show which group and question the suggestion(s) was drawn from. For example [A3] indicates this suggestion was drawn from the response of Group A to Question 3.



Only High and Mid-Priority Issues Included

- **Only the higher and mid-priority suggestions from the industry representatives given**
- **Suggestions edited/paraphrased to retain their sense when separated from the original question**
- **Lower priority suggestions not included**



Only High and Mid-Priority Issues Included

- Similar suggestions from different sessions and groups combined with the multiple sources cited. *For example, the annotation [A3, C2, C4] would be repeated similar comments from three different sessions*
- To see the original questions in context, look at the separate presentation “Consolidated Breakout Discussion Notes”



The Groups Were Focused on DOE Programs

- Since some of the questions specifically were aimed at improving the direction of existing programs, they thus presumed a program would happen; we did not ask industry if a program should happen
- This might create a “leading question” bias, but does focus the group to address issues that are DOE priority areas

For example: if the question were posed, ‘What type of R&D is needed to support Vision 21?’, a response of ‘Oxygen combustors’ does NOT mean that industry either wanted Vision 21 as a high priority or not, just that WERE such a Vision 21 to proceed, then DOE would be advised to look at oxygen combustors



Industry's Suggestions

R&D and Other Support Suggestions...



Barriers to Coal Combustion Surveys

State of Kentucky, August 1990

- Capital Cost
- Recent Oil and Gas Prices
- Operating Costs
- Possibility of More Stringent Regulation
- Space Limitations (now 15)
- Gas Clean-up Equipment Costs
- Solid Waste Disposal
- Flexibility (fuel, operational)
- Automation & Controls Cost (now 12)
- Time for Environmental Permitting
- Lack of Experienced Operators (now 17)

Orlando Workshop, January 2002

- Capital Cost
- Possibility of More Stringent Regulation
- Financial Risk (new)
- Time for Environmental Permitting
- Recent Oil and Gas Prices
- Cost of Obtaining (was 14) Environmental Permits
- Gas Clean-up Equipment Costs
- Operating Costs
- Solid Waste Disposal
- Flexibility (fuel, operational)
- Transportation Costs (was 13)



Component Discussion Areas Covered

- Advocacy Actions Where DOE Could Help Industry
- Clean-Up Systems / Technology
- Burners and Combustion Systems
- Burners and Combustion With Oxygen
- Oxygen Combustor/Flue Gas CO₂ Recycle
- Byproduct Sales
- Computational Modeling
- Condenser, Circulating Water, Cooling Improvement, Waste Heat Recovery
- Gas Turbine Development
- Hot Gas Filtration
- Instrumentation and Control
- Materials Development and R&D
- Oxygen Production
- Pressurized Feed Systems and Ash Letdown
- Combustion Technologies
- Program Issues



Combustion Technology Systems Areas Discussed

- **Program Issues**
- **Common Issues**
- **Pulverized Coal**
- **Advanced Coal-Fired Peakers**
- **Oxygen Furnaces**
- **Fluidized Bed Systems**
- **Hybrid Systems**



Advocacy Actions Where DOE Could Help Industry (1 of 2)

- Provide EPA advocacy to permit a limited number of DOE “No New Source Review” waivers to develop and demonstrate new technology; if goals are not met in demonstration, then allow a reasonable time to remedy [C3]

(High risk, high gain projects don't launch because of fear of NSR implications if the new technology doesn't work as expected; need waiver to allow first try of new methods. There would be little impact on U.S. pollution from these few demo units as they shake out the bugs of pioneering a technology, but big positive impact if the new technology proves successful.)

- To reduce hybrid system risk in State and public perception, suggest R&D for public relations and education campaign, Federal leadership, National policy [B3]



Advocacy Actions Where DOE Could Help Industry (2 of 2)

- **Power industry energy planning information is getting harder to obtain. This may require legislation, or FERC, EIA, EPA regulatory action. Information is drying up/aging due to competitive proprietary concerns, making it increasingly difficult to collect factual plant-level information.**
- **DOE should poll planners in industry and states to find what their information needs are, and recommend national energy data collection and dissemination (EIA, perhaps FERC). If ALL competitors have to reveal the same amount of information, then the playing field is level and rules are common and fair.**
- **Individual unit information like unit heat rate, unit fuel, nameplate rating, kWh generated in year, and emission rate of criteria pollutants should be collected and reported in one place by unit; retirement and construction plans collected in aggregate, and this energy planning info made available to all. [C3]**



Clean-Up Systems / Technology

- **Mercury removal from pulverized coal units [A1]**
- **Develop advanced combined multi-pollutant (NO_x, SO_x, Hg, particulate matter) collection systems, integrating environmental control subsystems, including new sorbents [A3,B1, C3]**
- **Development of coal preparation technologies (quality of coal) [C3]**



Burners and Combustion Systems

- Multi-fuel capability combustors [A2]
- Enhanced burner designs [A2]
- Low NO_x burner capable of controlling fuel-bound N₂ [A2]
- Catalytic combustion [A2]



Burners and Combustion With Oxygen

- Char combustion R&D (for air-blown and oxygen-blown systems) [B1]
- Investigate the impacts of oxygen-enhanced combustion on emissions [A5]
- Develop advanced cyclone burners for oxygen firing in slagging furnaces [A5]
- Oxygen combustors (burners) are needed for Vision 21 systems [B1]
- Research oxy-coal combustion [C3]
- CO₂ compression relevant to the use of oxy-coal [C4]



Oxygen Combustor/Flue Gas CO₂ Recycle

- How do flue gas recycle properties change with type of coal [C1]
- Impact of oxygen combustion/flue gas recycle on slagging and fouling characteristics in furnace [C1]
- Where is the best place to extract CO₂ for recycle? [C1]
- What is the impact of adding a flue gas recycle system on reliability? [C1]
- What are impacts on NO_x emissions and plant efficiencies with oxygen combustion/recycle? [C1]
- What are the impacts on operating and capital costs of oxygen combustion/flue gas recycle? What are the major criteria with regard to retrofitting an existing plant with oxygen/flue gas recycle? [C1]
- What is the impact of oxygen combustion/flue gas recycle on downstream SO₂ scrubbers [C1]
- Are technologies available now for oxygen combustion/flue gas recycle combustion systems? – what is the level of: maturity? availability?



Byproduct Sales

- Process ash already in ponds for reclaim for sale and use; ponds are being filled [C4]
- Develop better ways of producing good quality by-products (low NO_x, Low LOI) [C3]



Computational Modeling

- Fluid dynamics of CFB's [A1]
- Computational modeling of CFBs [A1]
- Modeling of two-phase flow, e.g. CFD [B2]
- To reduce hybrid system risk in off-design (normal) performance impacts (implication for materials), suggest R&D for modeling, also need modeling in integration vs. decoupling (e.g., gasifier/gas turbine [B3])



Condenser, Circulating Water, Cooling Improvement, Waste Heat Recovery

- **Develop new cooling system options to overcome regulatory constraints [C3]**
- **Condenser technology enhancement is needed [B1]**
- **Are there ways to improve the condensate cooling system, condensers, cooling towers, find ways to reduce terminal temperature difference? [C4]**
- **Develop uses for low-grade waste heat [C4]**
- **Develop no-slip air heater, avoid slippage, inefficiency, other problems [C4]**



Gas Turbine Development

- Improved syngas combustion needed [B1]



Hot Gas Filtration (1 of 2)

- Hot gas filters for CFBs [A1]
- Develop filters that operate at process temperatures (up to 2000 °F) [A3]
- Develop filter materials that can survive harsh environments emphasizing long-term durability testing of high temperature filters [A3,B1]
- Combine filter technology with gas separation technology [A3]
- Improve O&M and replacement (to reduce down time, etc.) [A3]



Hot Gas Filtration (2 of 2)

- Characterize ash properties under different operating conditions (fuel/ash impacts) [A3]
- Investigate chemical reactions within filter vessels when using sorbents [A3]
- Develop lower cost filtration systems [A3]
- Develop innovative mechanisms for online cleaning with improved efficiency [A3]
- Investigate additives for improved filter performance [A3]
- Develop filter materials suitable for operation at various temperatures [A3]



Instrumentation and Control (1 of 2)

- **Develop improved control of coal feeding, individual burner and fuel ratio controls for pulverized coal plant furnaces, individual burner/injector fuel flow rates-measuring, balancing [B4,A1,C4]**
- **Active combustion control systems [B1]**
- **Real-time monitoring of ignition, NO_x, LOI carbon burnout, corrosion (sensors and control) [B4, C3]**
- **Develop integrated controls for operability for slagging furnaces with enhanced-oxygen combustion**
- **Instrumentation to measure solids flowrate in pressurized systems are needed [B2]**



Instrumentation and Control (2 of 2)

- **Reliable level detection systems are needed for detecting solid levels in pressurized systems [B2]**
- **Durability of sensors: example: thermocouples and windows for optical sensors [B4]**
- **Smart systems (Artificial intelligence applied to plant operation on different fuels, ambient conditions, load, maintenance condition) to obtain lowest COE [B4]**



Materials Development and R&D

- **Cost-effective materials with improved mechanical properties for high temperature environments [B1]**
 - Materials of construction for CFBs [A1]
 - Materials research for supercritical units [A1]
 - Develop high-temperature, corrosion-resistant materials suited for use in enhanced oxygen slagging furnaces[A5]
- **Building high-temperature pressurized corrosion resistance and understanding of corrosion mechanisms (slagging behavior) [B1]**
- **Improve materials to allow flue gas ejection at lower temperatures, avoiding corrosion (there may be plume-rise issues as well) [C4]**
- **Effect of mixed fuels on corrosion (for co-firing of: biomass, tires, waste-to-energy, used oil products, etc.) [C4]**



Oxygen Production

- **Develop more cost-effective oxygen production: lower cost oxygen or lower purity oxygen [A5, C1]**



Pressurized Feed Systems and Ash Letdown

- Develop innovative pressurized feed systems and ash letdown (*e.g., motionless systems for letdown*) [B1,B2]
- Transfer pressurized feed and let-down lessons-learned from the chemical industry to the power industry [B2]
- Characterization / beneficiation of ash [B2]
- Innovative ash cooling designs for pressure letdown [B2]
- Improvement of solids flow, e.g., mechanical enhancements or additives to enhance pressurized feed [B2]
- Improve high-temperature valves needed for pressurized feed and ash letdown [B2]
- Improved pressurized vessel inerting systems [B2]



Combustion Technologies

Integrated Power Plant System Development



Combustion Technology Program Area Suggestions from Industry
020118-27



Program Issues

- **What goals, accomplishments are expected of CO₂ capture? [C1]** *there may be more need of outreach effort*
- **Continue development of Combustion Technologies; both -long term combustion technologies with commercial application beyond 10 years. Continue support of advanced combustion technologies (SCWO, MHD, catalytic combustion, etc.); and, short term combustion technologies with commercial application possible within 10 years, continuing support of emerging combustion technologies (GFBCC, CHIPPS, etc.) [C3]**



Common Issues

- **Desperate need for the improvement of the US infrastructure for the delivery of coal, fuel, and delivery of power by transmission [C4]**



Pulverized Coal (1 of 2)

- **Develop pulverized coal with near zero emissions [A1]**
- **Find ways to lower cost of supercritical steam generators ('boilers') [A1]**
- **Integrate design and material, reduce stress and corrosion on high-temperature components in supercritical and ultrasupercritical steam systems -- innovations in design may be as important or more important as innovations in materials [C2]**
- **Design, develop, and code high temperature materials for supercritical and ultrasupercritical steam system steam generator ('boiler'), turbine, balance of plant [C2]**
- **Evaluate slagging and fouling at high temperatures in supercritical and ultrasupercritical steam systems are important risk areas that need to be addressed, since tube temperatures and materials are different. [C2]**



Pulverized Coal (2 of 2)

- Establish better understanding of tube wastage in boilers (cost and reliability issues); changes to low NOx combustion have increased wastage, and some emerging technology burner development suggestions will likely also change wastage patterns [C3]
- Develop a steam cycle at or above 1500 °F [B1]
- How do you develop lower material cost for steam turbines and acceptable maintenance costs for 1400°F operations and above? [C2]



Advanced Coal-Fired Peakers

- **Peaking systems require low capital cost to be economically viable. Is a coal-fired peaker system economically feasible? A comprehensive study is needed to: [A4]**
 - Investigate various system options for coal-fired peakers
 - Characterize the associated economics/markets



Oxygen Furnaces

- Develop oxygen-enhanced systems to retrofit existing plants (model existing systems, etc.) [A5]
- Investigate ash/slagging characteristics for enhanced oxygen slagging furnaces [A5]
- Model a 100% oxygen fired boiler, including the effects on the GT [A5]
- Produce a technical/economic feasibility model of a new enhanced oxygen slagging furnace system concept that uses 100% oxygen
- Study the impacts of oxygen enhancement on heat transfer [A5]



Fluidized Bed Systems

- **Simultaneous combustion of fuel/waste in CFBs
[A1]**



Hybrid Systems

- To reduce hybrid system risk in integration vs. decoupling (e.g., gasifier/gas turbine), suggest pilot plant testing using a systematic approach [B3]
- To reduce hybrid system risk in off-design (normal) performance impacts (implication for materials), suggest defined materials oversight, lab R&D [B3]

